



# Transportation Synthesis Report

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## Rapid Construction of Structural Foundations

*Prepared for*  
**Wisconsin Highway Research Program**  
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*Prepared by*  
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*Transportation Synthesis Reports are brief summaries of currently available information on topics of interest to WisDOT technical staff. Online and print sources for TSRs include NCHRP and other TRB programs, AASHTO, the research and practices of other transportation agencies, and related academic and industry research. Internet hyperlinks in TSRs are active at the time of publication, but changes on the host server can make them obsolete.*

### **Request for Report**

The Wisconsin Highway Research Program's Technical Oversight Committee on Geotechnics requested a synthesis report on current research and state transportation agency practices in rapid construction of structural foundations. Specific interests included footings for bridges and retaining walls.

### **Summary**

Rapid construction techniques for foundations or footings are generally addressed as one element of the rapid bridge construction process. Typically, footings are mentioned in documentation on prefabricated substructure systems. FHWA's Web site on prefabricated bridge systems is an excellent resource for contacts in this area and for publications that address precast footings and other foundation elements of prefabricated bridge systems.

### **Current Research and Practices – Footings**

The following Web sites and publications contain information on rapid bridge construction with a particular focus on footings and foundations. Many projects described below contain **cast-in-place elements** and **precast footings**, key components of foundations built using rapid construction.

#### **FHWA – Prefabricated Bridge Elements and Systems Web site**

<http://www.fhwa.dot.gov/bridge/prefab/index.htm>

This site includes descriptions of innovative projects and links to research in progress, engineering contacts, and publications. See in particular links to Research (<http://www.fhwa.dot.gov/bridge/prefab/research.htm>) and to Publications (<http://www.fhwa.dot.gov/bridge/prefab/pubs.htm>).

The site includes a Prefabricated Bridges brochure (<http://www.fhwa.dot.gov/BRIDGE/prefab/brochure.htm>), which describes 15 projects, including two that use precast box piers that are post-tensioned to **cast-in-place concrete footings**:

- **Cross Westchester Expressway Viaducts, New York.** New York State DOT was required to maintain six lanes of congested traffic and limit construction on a restricted site during replacement of two major I-287 viaducts in Westchester County. NYSDOT accepted the contractor's value-engineering proposal to incorporate precast segmental voided pier sections for each of the 42 piers, which consisted of 8-foot match-cast segments vertically **post-tensioned together and to the footings**. The proposal also changed the cast-in-place deck to 10-foot-long by 9-inch-thick precast panels, 42 to 50 feet wide to match longitudinal construction stages, supported on pairs of multi-span continuous steel tub girders.
- **Route 9/Metro North Pedestrian Bridge, New York.** Building a pedestrian bridge in the village of Croton-on-the-Hudson involved site restrictions, a requirement for aesthetic design, and the need to limit disruption on a heavily traveled highway and a major commuter railroad. NYSDOT chose two prefabricated composite superstructure spans with concrete parapets to bridge the four-lane highway,

service road, and five sets of railroad tracks. Twelve-inch-diameter precast piles support three-section piers made of precast boxes stacked vertically and **post-tensioned to a cast-in-place concrete footing**, with precast parapets and a cast-in-place deck. Ramps are 35-foot-long precast concrete units and 20-foot precast stair sections, supported directly on precast columns with cast-in-place seats. Precast concrete's many available architectural treatments also enabled NYSDOT to meet the project's aesthetic goals.

**Puerto Rico. "Laying the Groundwork for Fast Bridge Construction," *Public Roads*, Nov./Dec. 2003**

<http://www.tfhrc.gov/pubrds/03nov/02.htm> (scroll about halfway down the page)

**Baldorioty de Castro Avenue Bridges, San Juan, Puerto Rico.** This rapid construction bridge project used cast-in-place footings, but project managers found other ways to speed construction. Crews drove piles and **cast footings in place** on one weekend, covered the work with asphalt, then uncovered it to continue work the next weekend, when they **erected and post-tensioned the prefabricated substructure** components. After the crews completed the first two substructures, they set the 100-foot-long superstructure span in place, complete with seven box beams, wearing surface, and parapets.

**New Hampshire. "Precast Concrete Dominates the Short-to-Medium Bridge Markets," *Better Roads*, August 2005**

<http://www.betterroads.com/articles/aug05a.htm> (fifth paragraph under the "Benefits of prefab bridges" heading)

A New Hampshire project described in this article includes **precast footings** in its **substructural system**. The project used precast superstructure members and a precast substructure with grouted splicers connecting footing units and abutment legs.

- J.P. Carrara & Sons, the off-site fabricator, cast the 48- by 36-inch-deep box girders using a very high-slump concrete mix. Crews assembled reinforcement in the forms, used Styrofoam to create voids, and filled the forms with the self-consolidating concrete. All **footers, abutments, and wing walls were precast off-site using self-consolidating concrete**, which sped up fabrication and reduced costs. Because SCC does not require a vibrator, one person worked on each pour rather than the three to five needed for conventional concrete.

**Current Research and Practices – Substructure Systems**

The following entries relate to substructure systems in general, rather than foundations and footings as separate system components.

**NCHRP Synthesis 324: *Prefabricated Bridge Elements and Systems to Limit Traffic Disruption During Construction***

[http://gulliver.trb.org/publications/nchrp/nchrp\\_syn\\_324.pdf](http://gulliver.trb.org/publications/nchrp/nchrp_syn_324.pdf)

This study describes a variety of prefabricated structural options, including prefabricated substructure systems, usually entailing segmental piers and bents. The topic is discussed at length throughout; see especially pages 20-22, 29-32 and 38-39 of the PDF, which include descriptions, drawings and more.

**Japan. "Bridge Fabrication Systems: Bridges on the Move," *TranScan 8* (Fall 2004)**

[http://trb.org/publications/nchrp/transcan\\_8.pdf](http://trb.org/publications/nchrp/transcan_8.pdf)

A survey of Japanese rapid bridge construction practices, this article identifies the SPER system, which uses stay-in-place concrete panels that double as formwork for cast-in-place concrete and as structural elements. The panels are stacked atop one another with epoxy joints, and allow crews to combine construction efforts for the **substructure** and structure. See also an implementation plan for SPER and other rapid construction systems from this scan at <http://www.fhwa.dot.gov/bridge/prefab/stip.htm>, as well as a summary of the scan survey at <http://www.fhwa.dot.gov/bridge/prefab/pbesscan.htm>.

**Texas. *Development of a Precast Bent Cap System*, January 2001**

[http://www.utexas.edu/research/ctr/pdf\\_reports/1748\\_2.pdf](http://www.utexas.edu/research/ctr/pdf_reports/1748_2.pdf) (42MB file)

This study focuses on precast bent cap systems, specifically connections to cast-in-place columns, precast piles, and vertical ducts. Foundations are not the specific focus of the study.

**Texas. *A Precast Substructure Design for Standard Bridge Systems*, September 1998**

[http://ultimate.fsel.utexas.edu/FSEL\\_reports/1410-2F.pdf](http://ultimate.fsel.utexas.edu/FSEL_reports/1410-2F.pdf)

This study also focuses on precast bent caps with a view toward durability and aesthetic appeal.

## **Research in Progress**

The following studies in progress or in process of publication focus on prefabricated substructural systems, which presumably will include information on connecting to various foundation configurations.

### **Washington State. “Precast Systems for Rapid Construction of Bridge Substructures,” August 2003–December 2005**

<http://rip.trb.org/browse/dproject.asp?n=7747>

This study looks to recent developments in building construction as a basis for developing systems for effective construction of **precast bridge substructures**. Instrumentation of a structure in the field will verify design recommendations.

### **TRB Committee AFF80. Problem Statements 2005: “Rapid Construction of Pre-Fabricated Substructure Systems for Durable and Sustainable Bridges,” TRB Design and Construction Group, Structures Section, Structural Fiber Reinforced Plastics Committee (AFF80)**

<http://gulliver.trb.org/publications/dva/rps2005/AFF80-RPS05.pdf> (page 10 of PDF)

This proposal addresses the use of fiber-reinforced polymers in **prefabricated substructure** system components, particularly as an alternative to precast concrete components. The proposing researchers suggest a view toward durability, design and physical characteristics, and responses to stress.